A Study of the Five Ohio Portland Cement Operations in 1985

by

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Abstract

Portland cement is a finely ground, manufactured mineral product that when combined with water, sand, gravel, and other materials forms concrete – the most widely used construction material in the world. The Portland cement industry in Ohio consists of five plants; Fairborn, Paulding, East Fultonham, Middlebranch, and Sylvania. These plants combine to produce 2,500,000 tons of cement a year.

Of these plants, Fairborn is the largest and most fuel efficient. Paulding is innovative in using industrial solvents as a fuel addition for its kiln. Middlebranch is the smallest plant (600 tons per day), and gets its stone from a sister plant. East Fultonham is a sister plant to Sylvania. Sylvania has been shut down for almost two years, so East Fultonham uses the dormant plant as a terminal for northwest Ohio.

There are three different cement processes used in Ohio. The wet, dry, and semi-dry kiln process. The wet process is used in three plants; East Fultonham, Paulding, and Sylvania. The dry process is used in Fairborn, and the semi-dry process is used at Middlebranch. Of the three processes, the dry process is the most fuel efficient, so

The complete Abstract is not available.

Introduction

Purpose

The purpose of this investigation is to examine the materials used and the manufacturing processes of Ohio's five Portland cement producers: Middlebranch, East Fultonham, Paulding, Fairborn, and Sylvania. The ultimate aim of this study is to evaluate the economic outlook of the industry in general in order to recommend ways of improving the operation and production of Ohio's Portland cement industry.

Procedure

The procedure for investigation in this report was library research as well as personal interviews. Personal interviews were conducted with representatives from each of Ohio’s five producers to obtain data about the process used, production figures, problems with the plant, and future improvements for their plant. General information concerning the process and chemistry of cement manufacturing was obtained from the Portland Cement Association, a research and market development organization representing 75% of the Portland cement producers in the United States.

General Statements on Cement Industry

History of Portland Cement

Portland cement is a hydraulic cement produced by pulverizing clinker consisting essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulfate as an interground addition (ASTM, 1981, C-150). Cement has a long history, dating back to First Century A.D. when the Romans mixed lime with volcanic ash, called “pozzolana.” The Roman Pantheon and the Coliseum were both constructed of this material. The developments leading up to the discovery of Portland cement began in England about 1756, when John Smeaton found that lime mortar containing some clay material had better hydraulic properties. About 1796, natural cement was produced by burning cement rock in vertical kilns. The burning was found to produce greater strength. The first true Portland cement was produced in 1824 by Joseph Aspdin, an Englishman. Aspdin coined the term “Portland” because the set cement looked like the stone quarried from the Isle of Portland. The first Portland cement in the United States was made in 1871. The switch to a rotary kiln in 1886 and high temperature burning are the latest major advances of the industry (SWPC, 1967, p.1).

Patterns of Using Cement

Nearly all Portland cement is used to produce concrete. Although cement comprises only about 12% of the weight of concrete, it is the key ingredient. The primary purchasers of cement are ready-mix concrete manufacturers, concrete products producers, and building contractors. About 2/3 of the cement sold in this country is to ready-mix concrete manufacturers. The block, brick, pipe, and precast products of concrete product producers consume about 13% of the cement, and 7% of the cement is purchased by building contractors. The table below lists these and other primary Portland cement purchasers (PCA Report, 1984, p.6).

	1973	1982	10 yr. Ave.
Building Materials Dealers	8.2%	5.8%	7.3%
Concrete Product Mfg.	13.7	11.9	13.4
Ready-Mix Concrete	66.1	68.5	66.6
Highway Contractors	7.0	4.4	5.9
Other Contractors(Oil Wells)	2.8	7.1	4.7
Government Agencies	0.4	0.3	0.5
Miscellaneous	1.8	2.0	1.6

Different types of Portland cement are manufactured to meet different physical and chemical requirements for specific purposes. The American Society for Testing and Materials (ASTM) Designation: C150 provides for eight types of Portland cement (ASTM, 1981, C-150). Ohio cement plants produce mostly Type 1 cement.

Type I	for normal use
Type IA	normal air-entraining cement
Type II	moderate sulfate resisting or heat of hydration
Type IIA	moderate air-entraining
Type III	high early strength
Type IIIA	high early strength air-entraining
Type IV	low heat of hydration
Type V	high sulfate resistance

The cement consumed in a given state in any given year depends on many influences; these include the local availability of competitive building materials, the extent and success of cement promotion in the area, the maturity of the state’s construction market, and the state’s economic growth rate and immigration pattern (PCA Report, 1984, p.6).

Cement in Ohio

Almost 20% of the limestone quarried in Ohio is used for concrete and about 10% used directly for the manufacture of Portland cement. In 1984, Ohio limestone produced 2,445,000 tons of Portland cement, a total representing a 24% drop in production since 1979. Ohio’s national production ranking has dropped from 6th in 1972 to 8th in 1982 as shown in tables below (PCA News, 1985).

National Production of Cement

(in 1000's of tons)

1972			1982		
1.	California	8,491	1.	Texas	9,185
2.	Texas	6,789	2.	California	6,034
3.	Florida	5,001	3.	Florida	4,081
4.	New York	3,633	4.	Louisiana	2,453
5.	Illinois	3,606	5.	Illinois	2,309
6.	Ohio	3,340	6.	New York	2,272
7.	Pennsylvania	3,272	7.	Pennsylvania	2,207
8.	Michigan	3,231	8.	Ohio	2,040
9.	Georgia	2,506	9.	Oklahoma	1,857
10.	Louisiana	2,358	10.	Georgia	1,775

Ohio Consumption of Portland Cement 1979-1984

(in 1000's of tons)

1979	1980	1981	1982	1983	1984	%Change 1979-84		%Change 1983-84	
						Ohio	U.S.	Ohio	U.S.
3202	2650	2326	2033	2212	2445	-23.6%	-5.0%	+10.5%	+14%

Cement production has dropped this drastically for several reasons. First of all, the profit margin for cement sales had gone from an average of 10.3% in 1979 to about 0.3% by 1982 (PCA Report, 1984, p.17). This decrease is attributable to a decrease in construction starts in Ohio and a sharp increase in transportation and energy costs since the early 1970's. Ohio's construction industry began a sharp downward trend because of a population emigration southward to the "sun belt." Energy costs have increased steadily since the Arab Oil embargo. Energy costs in relation to the value of cement shipments have increased from 16% in 1971 to 28% of the shipment value in 1981 (PCA

Report, 1984, p.17). Therefore, recommendations must be made to improve the manufacturing process or marketing of cement, or possible to eliminate some Portland cement plants.

Economics of Cement

Cement manufacturing is a regional industry primarily because of the low value-to-weight ratio of the product. Cement plants tend to be located within 150 to 200 miles of their target markets. Beyond that distance, land transportation becomes cost prohibitive. In some cases, river or lake barge traffic increases the target market distance (Personal Communication, T. Wright).

Because of the regional nature of cement markets, the ideal plant size is one that combines a maximum production efficiency and correct expectations of the product demand of the area (Leford, 1983, p.143). In the cement industry, plant size and plant efficiency are directly proportional. Therefore, a plant in a specific geographic location should be as large as possible to increase efficiency, yet not so large as to remain idle for long periods of time.

Cement manufacture is one of the six most energy-intensive industries as ranked by the energy required to produce a ton of product (PCA Report, 1984, p.9). The major costs to a cement plant, in descending order, are the costs of labor, fuel for the kiln, and power for grinding. In a dry process plant, fuel and power exchange rank.

Energy represents nearly 1/3 of the manufacturing costs of cement.

Process of Cement Making

Cement manufacturing is strictly a regional industry mainly because of the low value-to-weight ratio of the product. The main factors determining the location of plants in the cement industry are the market, the transportation available, the abundance of raw materials, and the availability of fuel and power. A delicate balance must be reached between raw material sites, target markets, and transportation for the finished product. In most cases, it is much more cost effective to locate the plant at the quarry site and save the farthest shipping for the finished product, which is 1/17 by weight of the gross raw materials used (Personal Communication, J. McKay). This problem may be overcome by cheap transportation, however, such as river barges.

Cement manufacturing begins at the quarry. Illustration II in the appendix shows the process well. Most limestone for use in cement is quarried. However, if high quality stone is available at a reasonable depth, subsurface mining may be used. The usual steps in quarry operation include stripping the overburden, drilling, blasting and breaking, and loading the stone to the crushers (Leford, 1983, p.144). The raw materials are then brought into the plant and ground to 3/4” size. The ingredients of

The cement mix are then proportioned correctly and ground together to powder size. At this point, the split between wet and dry processes occurs.

Most older plants are wet process plants. The flow of materials in the wet process consists of adding water at the grinding mill to form a slurry. The slurry is pumped through vibrating screens until all passes through a mesh screen. The slurry is then blended again before being sent to the head of the kiln (Ohio Ready Mix, p.21).

The wet process came about due mainly to wet raw materials, the efficiency of wet blending, and the low fuel costs at the time most of these type plants were built. The wet process requires much more fuel (1500 kcal/kg clinker) for the kiln relative to the amount of fuel required for the dry process (850 kcal/kg clinker) because all of the excess water added for blending and pumping purposes must be driven off from the slurry before any chemical reactions can take place in the kiln (Leford, 1983, p.139). Although this extra fuel cost has discouraged construction of new wet process plants, the wet process does have the advantage of being able to use Ohio’s high sulfur coals. Since the wet process is an open system, the sulfide-rich gases created by the high sulfur coal can escape very easily and are removed in the stack by scrubbing devices. The sulfur content of the coal actually helps the mix by decreasing the amount of Gypsum (CaS04 2H20) to be added to the resultant clinker.

The very earliest cement plants were dry process; recent sky-rocketing fuel costs, as well as improvements in dry mixing and pumping systems, have created a resurgence of dry process plants. In fact, every cement plant built since the Arab oil embargo has been dry process (PCA Report, 1984, p.21). As previously stated, the dry process requires less energy in the calcination process than does the wet process and thus lowers fuel costs. Hot gases (up to 1200 degrees F.) from the head of the kiln are fed into a stack of pre-heating cyclotrons. The result is up to 40% calcination of the carbonates prior to kiln entry, and the kiln can be shortened (Personal Communication, T. Wright). Because less heating and shorter kilns are required for the dry process, the production rates are relatively high. However, some problems are caused by the fact that the pre-heater is a closed system. Since kiln gases are used to preheat the raw materials, it can cause a complicated process-imposed alkali problem if the chemistry of the fuel is incorrect. Chlorides, Sodium, Potassium, and especially sulfur gases produced from the burning of Ohio coal can not escape the system and can potentially block the pre-heater. To correct this problem, the gas stream is usually monitored, and when alkali levels become too high, some of the gas stream is drawn off. Removing some of the gas stream eliminates the problem gases, but it also lowers the efficiency of the system (Personal Communication, T. Wright).

The semi-dry kiln process is a relatively new process designed in Germany. It has the advantage over a dry process of lower installation costs, but maintenance costs are high. The semi-dry process provides somewhat less precalcination of the mix, but is more affordable and easier to add on to an existing wet process kiln.

The pre-heater in a semi-dry kiln consists of a large drying grate which moves on a conveyer-type system. The raw materials are spread 6 inches to 8 inches thick on the grate and the hot kiln exit gases pass beneath and through the mix. An added advantage to this process is the natural scrubbing of the sulfate gases that takes place in the pre-heater. Once through the drying grate, the gases are relatively sulfur-free (Personal Communication, R. Langhoff).

Chemistry of Portland Cement

Limestone suitable for Portland cement manufacturing must meet several criteria. The stone must be low in $MgCO_3$, close to the surface, near transportation and power sources, and in the case of the wet process, close to an adequate water supply. Chemically speaking, an ideal limestone would have Ca, Al, and Fe constituents. However, Ohio limestones are very pure and most Portland cement producers are forced to use a stone with a $CaCO_3$ content of over 90%. The ideal plant location achieves a balance among these criteria.

The limestone should have as little of $MgCO_3$ as possible in order to meet ASTM standards of less than 6% total MgO in the final product (ASTM, 1981, C-150). Any MgO above this amount will not react in the kiln and will remain as the mineral periclase. This is dangerous because periclase hydrates slowly, and through time will form brucite [$Mg(OH)_2$]. Brucite has twice the volume of periclase, and this expansion will result in disruption of the concrete (Knill, 1978, p.269).

The principal oxides in Portland cement which combine during the burning process to form the cement are SiO_2, Al_2O_3, Fe_2O_3, and CaO. The raw materials used in Ohio to supply these oxides are listed below (Ohio Ready Mix, p. 22).

CaO	Fe_2O_3	SiO_2	Al_2O	$CaSO_4$	MgO
Clay	Blast Furnace	Clay	Clay	Gypsum	Limestone
Limestone	Flue Dust	Limestone	Limestone		
Shale	Clay	Sand	Shale		
Slag	Shale	Shale			

The raw material mix will usually contain 85% limestone with the remaining 15% divided up among various constituents to balance the particular chemistry of the base limestone.

The Cement Kiln

The cement kiln is a long steel cylinder lined with fire brick up to 700 feet long and 20 feet in diameter. It is set on a flat slope of from 3/16 inch to 7/8 inch per foot so that gravity flow is induced by the rotation of the kiln. Powdered coal is introduced and ignited at the end of the kiln to provide the necessary heat of formation for the new compounds to be formed (2700-3000° F). The compounds formed in Portland cement are listed below (Leford, 1983, p. 141).

Compound	Oxide Composition	Stiochiometric Composition	Common Abbreviation	Appoximate % in type I
Tricalcium Silicate (Alite)	(Ca0)3Si02	Ca3Si05	C3S	45%
Dicalcium Silicate (Belite)	(Ca0)2Si02	Ca2Si04	C2S	27%
Tricalcium Aluminate	(Ca0)3A1203	Ca3A1206	C3A	11%
Tetracalcium Alumino-ferrite	(CaO)2Fe203 to (Ca0)6(A1203)2 (Fe203)	Ca4A12Fe2010	C4AF	8%

At the head of the kiln, the raw material passes through chains which are used to trap any remaining heat. The mix passes through several stages once inside the kiln. Loss of water occurs up to about 1650°F, when calcination of the carbonate occurs (C02 is driven off). At about 2440°F, the first liquid forms, and fusion of different elements occurs at their respective temperatures of formation up to 2800°F (Leford, 1983, p.141).

As the compounds form, they aggregate into marble-sized balls called clinker. The clinker is cooled, and then either sent to the grinding mill or stored for future grinding. Most cement plants have a higher grinding capacity than clinkering capacity so that large supplies of clinker can be built up for grinding during periods of peak demand, or kiln shut down. The final grinding is done with the addition of 2% to 5% gypsum ($CaSO_4$ $2H_2O$) depending on the type of cement being manufactured. The amount of gypsum and the size of the cement are the two primary controls in the setting properties of the cement. Gypsum extends the hydration period for the cement by slowing the reaction between C_3A and water. The fineness of the cement actually controls the setting of the cement more than the gypsum content. The finer the cement is ground, the more gypsum that must be added to inhibit hydration (Personal Communication, T. Wright). This final grinding with gypsum reduces the clinker to a powder so fine that more than 90% will pass through a screen with 40,000 openings per square inch, and 80% will pass 100,000 openings per square inch. This fine powder is now Portland cement, and is ready to be bagged, shipped, or stored for future use.

Survey of Ohio Cement Manufacturers

Fairborn (Personal Communication, T. Wright)

Production Data

The Southwestern Portland Cement Company's Fairborn plant is the largest producer of cement in the state. The plant is rated at 600,000 tons per year by the Portland Cement Association, and actually produces about 1875 tons of mostly Type I cement per day while working 80% of the year. Because of a modern kiln operation, Fairborn produces a very low cost clinker. This benefit is offset, however, by an inefficient high cost finishing mill. Fairborn is also a union plant which hinders its ability to compete with the non-union plants to the north. Fairborn's limestone reserves should supply the operation for about 50 years at the present rate of use, but not all of this stone is easily obtainable. The SWPC has had problems obtaining additional property because of local zoning laws.

The raw mix at Fairborn consists of 81%-83% limestone, 0.5%-0.75% Fe02 by-products, and the remaining percentage of surface clay. Sand may be added if the silica content of the clay is too low.

The limestone, from the Upper Brassfield Formation (Silurian), is quarried by SWPC in northern Greene and Montgomery Counties. In 1983, the SWPC quarry in Greene County produced 680,576 tons of limestone, and the

Montgomery County quarry produced 22,788 tons for use in Portland cement manufacture (Sneeringer, 1983, p.16). The Fe02 by-products used in the mix are purchased by the company. Increased EPA standards due to the Clean Air Act Amendments of 1970 have caused some of the sources of Fe02 to dry up. Therefore, brokers now supply this raw material. The silicon and aluminum for the mix at Fairborn are provided by surface clays. To ship the clay, SWPC purchases surrounding farmland, strips off 30-40 inches of the decomposed feldspar clay from the surface, reclaims the land, and leases it to local farmers until sold. The company produced 34,175 tons of clay from Greene County in 1983 (Sneeringer, 1983, p.78).

The chemical compositions of the raw materials used by SWPC are listed below.

<u>Limestone</u> <u>Analysis</u>

CaO	47.14%
C02	40.82%
Si02	4.20%
Mg0	3.40%
A1203	2.09%
Fe0	0.54%
Fe203	0.44%
FeS2	0.02%

(Stout, 1941, p.147)

<u>Clay</u> <u>Analysis</u>

Si02	78.52%
A1203	10.70%
Fe203	7.06%
Ca0	2.79%
Mg0	1.22%
Ti02	2.78%

(from SWPC labs)

Manufacturing Process

The Fairborn cement plant has the most modern clinkering operation in the state. In 1974, SWPC built a German designed pre-heating system. The previous wet process system which had been in operation since 1925 produced too many particulates for the Clean Air Acts of 1970. SWPC was faced with ether a large overhaul of the burning system or replacement of the old kilns. The company decided that a complete new process should be installed, and this decision has resulted in substantial fuel and labor savings.

With the new system, raw materials are fed into the top of the 225 foot high pre-heater in which four different cyclotrons provide the necessary pre-calcination of the carbonates. About 30 seconds are required for this to take place. The 210 foot kiln is fed by the pre-heater at about 140 tons per hour. The fuel used is pulverized coal, which provides about 11,500-12,000 Btu to the system. About 12% of the coal ash remains in the raw mix following burning. However, the pre-heating does have some difficulties handling high sulfur coal. The problem is solved by removing some of the gas stream from the pre-heater when the volatile content becomes too high. This problem is discussed above in the “Process of Cement Making.”

Limitations

The Fairborn plant has several weaknesses. First of all, the union labor at the plant creates an added expense to a product in which pennies a ton can make or break a company. Secondly, the clinker must be transported seven miles by rail to the grinding mill which adds a completely unnecessary and costly step to production. Thirdly, the grinding operation is out of date and uses too much electric power to produce the product. Also, the reserves of the plant are not adequate. A final weakness is the use of high sulfur coal which causes a loss of efficiency in the pre-heating system.

Suggested Improvements

Mainly because of the new dry process kiln, the Fairborn plant is one of the healthiest in the state. However, by improving on the above problem areas, the plant could increase its efficiency and thus lower the production costs. Further study by the company should be made to determine the economic feasibility of these suggested improvements.

The plant should attempt to formulate a better working agreement with the union force in order to become more competitive. Fewer worker benefits or wages more competitive with non-union plants will mean a lower price and a more competitive product, thus providing more work and higher gross earnings in the long run.

The problems with clinker transportation and grinder efficiency can be solved together. By overhauling the grinding operation and relocating it at the kiln site, some costly transportation will be avoided, and the efficiency of the grinding will be improved.

The problem of reserves must be tackled from a public relations standpoint. Southwestern Portland Cement must convince the city of Fairborn that the cement plant is vital to the well being of the city and concessions to the zoning laws must be made in order to allow the plant to obtain more and better stone for future operations.

Paulding (Personal Communication, G. Hoffman)

Production Data

The Penisular Division of General Portland Incorporated is located about three miles north of Paulding, Ohio, in Crane Township. The plant is one of nine owned by General Portland which helps to make it the third largest Portland cement producer in the nation (PCA Report, 1984, p.11). Paulding is an isolated rural location with completely flat topography located about 50 miles south of Toledo, and 15 miles east of Ft. Wayne, Indiana.

Paulding has the capacity to produce 540,000 tons per year, but for the past 3 or 4 years, it has operated at only 50%-60% capacity due to reduced demand. Type I and Type IA cement, as well as some masonry cement is produced. Depending on demand levels and pricing, the plant has roughly a 120-150 mile delivery range. The Paulding plant has raw material reserves of at least 100 years. Because of plentiful surrounding farmland and nearly horizontal limestone beds, acquisition of more reserves is not a problem.

Materials Used

Paulding began quarrying operations in 1951. The quarry consists of about 60 foot of overburden and then 45 foot of clay and glacial till. This clay supplies the silicon and alumina necessary for the raw mix. In 1983, 85,483 tons of clay were quarried. Below this caly lies the Detroit River and Dundee Limestones (Devonian). About 15-20 foot of dolomite must be removed to expose the 32 foot of limestone that can be used in the raw mix. The dolomite, useless to a cement plant, is sold to the neighboring France Stone Company who sell it as road metal. The Detroit River and Dundee Formation supplied 340 to 390 tons of limestone in 1983. When the quarries are exhausted, General Portland will reclaim the land. Several alfalfa fields currently surrounding the plant are former quarries.

The chemical compositions of the limestone and clay are as follows:

<u>Limestone Analysis</u>

$CaCO_3$	96.48%	> very pure
$MgCO_3$	1.71%	> carbonate
Ca	53.90%	
Si	1.25%	
Mg	0.82%	
K	0.35%	
Al	0.33%	
S	0.29%	
Fe	0.07%	

9/84 from lower limestone
Strata 76’-96’

(Paulding Lab)

<u>Clay Analysis</u>

$CaCO_3$	9.25%
$MgCO_3$	5.79%
Si	63.08%
Al	16.75%
Fe	5.67%
Ca	5.19%
K	4.45%
Mg	2.76%
S	0.07%

(Paulding Lab)

Any Fe and Si shortfalls in the clay are corrected by adding sand and mill scale iron supplied by a broker. Gypsum for the mix is purchased from Michigan.

Manufacturing Process

The Paulding plant's manufacturing process consists of two wet process kilns. Clinker is produced almost year round because the plants grinding capacity is 30%-40% higher than its clinkering capacity. This excess clinker is stored in large covered piles at the plant site. When grinding, the stored clinker is combined with fresh clinker to assure quality control. Due to a small (30,000 ton) product storage area, the plant cannot shut down for more than six weeks at a time. Because of the dual kilns, at times of low demand the plant may elect to run only one of the kilns at a time. But this lower capacity means higher product cost and is avoided whenever possible. The kilns are fired by 60%-70% coal. The remainder of the fuel is obtained from hazardous waste hydrocarbons such as industrial solvents. This type of fuel is unique to the cement industry in Ohio. A fuel broker, Cystek, Inc., supplies the waste and is responsible to certify its contents. Specific parameters are set by General Portland such as viscosity, per cent solids, per cent moisture, Cl content, and Ba content that must be met by the fuel broker. Currently, no carcinogenic materials such as Benzene or Polychlorinated Biphenyls are accepted. The solvents are shipped in, mixed in a larger tank, and fed into the kiln along with the pulverized coal to produce the necessary Btu's for the clinkering process.

Limitations

Overall, the General Portland plant at Paulding has some strong points. It has excellent raw material resources and an innovative fuel outlook with the burning of industrial wastes. There are a couple of weaknesses which should be explored, however. Primarily, the lack of storage facilities for the finished product demands that the plant start up and shut down at close intervals. This is not an efficient way to operate. Also, due to the current high price of fossil fuels, the wet process in general is relatively expensive. Operating two kilns has two benefits. In times of low demand, the plant can run on one kiln, and if a breakdown in one kiln occurs, the other can still operate. But two kilns also create a labor problem. If 70 men are required to run the dual kiln system, about 50 will be needed for the single kiln. Thus a 50% drop in production occurs with only a 30% drop in labor force.

Suggested Improvements

The first and easiest step in improving the Paulding operation would be expanding the finished product storage facilities. This would cut down on the numerous current start up and shut down periods. Any other improvements would involve a major overhaul of the clinkering process by implementing a more modern dry process and using only one kiln to eliminate wasted labor.

East Fultonham (Personal Communication, J. McKay)

Production Data

The Columbia Portland Cement Company’s East Fultonham Plant is located in southwestern Muskingum County in Newton Township. The plant was built in 1924 when a limestone quarry used for soda ash production was expanded for Portland cement manufacturing to take advantage of the overlying shale deposits. The plant produces mostly Type I cement and has a capacity of 600,000 tons per year. The actual production of the plant is about 2,000 tons per day. By acquiring additional property around the plant, Columbia projects the reserves of the area at about 70 years.

Materials Used

The raw material mix at East Fultonham consists of 85% limestone, 12% shale, and 3% sand. The limestone and shale come from the Maxville Formation of Mississippian age. Since 1952, East Fultonham has operated the only underground mine in the state for the purpose of Portland cement manufacture. The mine, named the Jonathan Mine after nearby Jonathan Creek, is adjacent to the cement kiln. Fifteen acres per year were removed from the mine producing 75 miles of tunnels into the hillside. The mine is currently nearing exhaustion, and Columbia has begun working the Lyle Quarry, just southwest of the plant. The mine and the quarry together produced 351,415 tons of limestone in 1983. The chemical composition of this Maxville limestone is listed below. The shale sequence overlies the limestone formation, and 35,992 tons were removed for cement manufacture in 1983. (Sneeringer, 1983, p.53) The sand used in the raw mix to raise the silica content comes from the nearby Muskingum River, and gypsum is shipped in from Michigan.

<u>Maxville Limestone Analysis</u>

96% $CaCO_3$

CaO	53.90%
CO_2	42.88%
SiO_2	1.65%
MgO	0.40%
Al_2O_3	0.35%
H_2O	0.16%
FeO_2	0.30%
FeS_2	0.12%
TiO_2	0.03%
Fe_2O_3	0.02%
K_2O	0.07%
Na_2O	0.02%

(Lamborn, 1951, p. 242)

Manufacturing

The manufacturing process at the East Fultonham plant consists of two wet process kilns. The kilns are each 450 feet long and have diameters of 14 ½ feet and 12 feet respectively. Pulverized coal is used exclusively as the kiln fuel. Approximately 25 pounds of coal are required to produce 100 pounds of cement. Movement of raw materials is handled quite well at the East Fultonham plant. The limestone-shale crusher is located down in the mine and a remote-controlled automatic raw material feed system sends the crushed stone upward to the plant. This eliminates one loading and one hauling step for the stone.

Limitations

The main problems with the East Fultonham cement plant lie in the underground mine. Subsurface mining of limestone creates additional costs to an ingredient which supplies 85% of the raw material mix. As a result of subsurface mining, the crusher is located down in the mine. This is efficient when the stone comes solely from the mine, but any stone quarried at the surface must be transported down into the mine for crushing. East Fultonham’s other problems are similar to most plants in Ohio; a dual kilned wet-process system is not as fuel efficient as the modern dry process kilns.

Suggested Improvements

The subsurface mining problem is soon to be solved due to exhaustion of the stone at depths economically feasible to recover. The primary crushing unit currently in the mine should be brought to the surface closer to the Lyle Quarry in order to eliminate unnecessary transportation of the limestone and shale. This would eliminate moving the raw materials down into the mine to be crushed and back out to the kiln. The wet process kiln is something the company must cope with, as replacement is not justified in today’s sluggish market. Increased awareness towards fuel efficiency should be observed, however.

Middlebranch (Personal Communication, R. Langhoff)

Profile Data

The SME Cement Company near Middlebranch is currently shut down and probably will be for at least a year. When in production the plant could produce 600 tons of cement a day. The plant is a non-union plant which undersells its competitors because of a pay base of about five dollars and hour less, and fewer laborers working the plant. The plant is not very large, so most of its product is sold in nearby Akron and Cleveland.

The SME Bessemer plant in western Pennsylvania currently supplies the limestone for the Middlebranch plant, the reserves at Bessemer total about 25 years. If the quarry at Middlebranch were to be reworked, the stone could supply the plant for about 14 years. Middlebranch’s quarry has nine years of reserves and the old Diamond Cement Plant has about five years of reserves. The Diamond Cement Plant is also located in Middlebranch. Upon closing, the Diamond plant was purchased by SME for its equipment.

Raw Materials

The limestone used at the Middlebranch plant was previously from the Putnam Hill limestone (Pennsylvanian). The stone is now shipped in by truck from the company’s Bessemer plant (from the Vanport Formation). SME owns very large quarries in Mahoning County in Ohio and in western Pennsylvania. The company quarries stone for road metal and dimension stone and uses the fines for its cement operations in Bessemer and Middlebranch. This saves the Middlebranch plant two dollars per ton compared to stone from their quarry on site. Middlebranch produced 109,406 tons of limestone in 1983, but has produced very little since then. (Sneeringer, 1983, p.55) The clay used in the raw mix is stripped from the 25-60 feet of glacial till overlying the Putnam Hill Formation. The plant stripped 9,913 tons of clay from the till in 1983. Gypsum added during the grinding of the clinker is supplied by U.S. Gypsum from Michigan. Raw material compositions are listed below.

Limestone Analysis

Loss of Ignition	22.080%
Silica	5.940%
Alumina	2.030%
Iron Oxide	1.090%
Calcium Oxide	57.240%
Magnesium Oxide	1.380%
Sulfur	0.310%
Potassium Oxide	0.600%
Sodium	0.008%
Phosphorous Pentoxide	0.123%

(SME Lab analysis: Putnam Hill Limestone, Marlboro Twp. Quarry III)

Clay Analysis

Silica	68.96%
Alumina	12.64%
Iron Oxide	4.32%
Calcium Oxide	4.22%
Sulfur	0.04%
Magnesium Oxide	3.02%
Loss of Ignition	5.88%

(SME Lab analysis at Royer #3 hole)

Manufacturing Process

The Middlebranch plant operates one of only eight semi-dry process consists of a six to eight foot layer of material spread on a drying grate before entering the back of the kiln. This partially dries the mix, and also acts as a scrubbing agent for the sulfur in the exit gasses. Pulverized Ohio coal provides the necessary 11,000 Btu for kiln operation.

Limitations

The primary weakness in the operation of the Middlebranch plant is shipping the limestone in from western Pennsylvania. This may be cheaper for the plant in the short run, but it is a waste of energy and manpower and is probably not feasible in the long run. It is necessary now, though, because of the lack of significant limestone reserves in Middlebranch.

Suggested Improvements

By expanding their reserves and improving the quarry operation, Middlebranch could eliminate unnecessary transportation of the limestone. A second improvement which has been suggested by the company and probably will be implemented is a three million dollar expansion of the drying system of the Lepol kiln. Any significant improvement in the cement industry would warrant installation of this drying improvement.

Sylvania (Personal Communication, J. Evans)

The Sylvania cement plant was recently purchased by Columbia Portland from SME. The roof over the two wet process kilns collapsed in the winter of 1984, and the company has not taken any steps to repair it. Because no clinker has been produced at the plant for about two years, an evaluation of the production, materials, and limitations of the Sylvania plant will not be made.

Competition from the large Dundee cement plant 25 miles to the north as well as the current cement market is probably preventing the repair of the Sylvania plant. Columbia currently uses the plant as a terminal for some of the cement produced at East Fultonham.

Future Outlook and Recommendations

Energy costs for Portland cement production will continue to rise in the future. To compensate for this, Portland producers must make every effort to increase plant efficiency. Whenever possible, plants should change from wet to dry process in order to save labor and fuel. In the future, improved fuel mixtures and eliminating any waste heat in the kiln will be necessary to remain competitive.

An upswing in construction due to a more promising economy is expected to increase cement consumption in the near future. Repair of the interstate highway system and new developments in the uses of cement should also increase the consumption of cement. The insulating qualities of concrete will be beneficial in the future for more fuel efficient buildings. Current technology has created high strength cement which allows concrete to compete with steel in building construction. These and other developments should help cement to remain a necessary construction material in the future.

The growing concern over our environment may be the best promotion cement consumption could have. Concern over safety, noise pollution, energy conservation, water supply, and sewage and hazardous waste disposal will lead to increased use of cement for protection of the environment. The disposal of hazardous wastes is potentially a substantial money maker for the cement industry. First of all, the ever increasing supply of high level nuclear wastes must be disposed of. Cement is used to contain these wastes in their final storage places.

A potentially more important use for a cement plant does not involve the production of the actual cement. Many toxic wastes are now produced which could be incinerated in the high temperatures of a cement kiln. Probably the best way to destroy the carcinogen Polychlorinated Biphenyl (PCB) is to incinerate it in a cement kiln. (Personal Communication, G. Hoffman) The PCBs will burn and provide high heat values while basically emitting only excess nitrogen into the atmosphere. All of this will occur without any adverse effects on the cement mix. If the political barriers for this problem can be broken, this could be the saving grace for many faltering cement plants. The cement of the future may become a by-product in a hazardous waste incinerator!

Conclusion

Upon evaluation of the manufacturing process, the materials used, and the economic outlook of the Ohio Portland cement industry, two main conclusions can be drawn.

The Ohio cement industry is an aging industry in today’s high tech world. Fairborn is the only plant whose kiln has been built since 1960, and three plants still use the inefficient wet process. All plants have relatively old finishing grinders which are large power consumers. Also, in some cases the reserves of the plants are dwindling quickly.

The market for cement in Ohio is currently not very good, but a resurgence is slowly occurring. Last year, cement consumption in Ohio increased by 10.5%, (PCA News, 1985), but labor and energy costs are as high as they’ve ever been. Profit margins have dropped drastically because a saturation of the market due to a drop in construction has created fierce price competition among the companies. The industry is on an upswing, but still has a long road ahead.

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McKay, James. Chief Engineer, Columbia Portland Cement Company, East Fultonham, Ohio. January 25, 1985.

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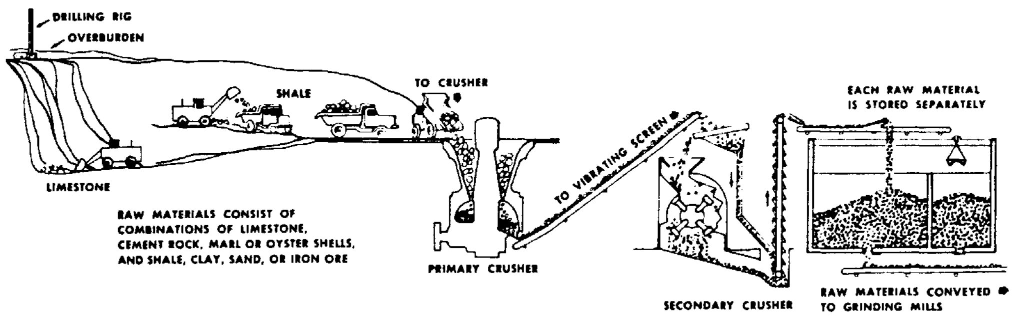
The complete Appendix is not available.

Ohio Portland Cement Producers

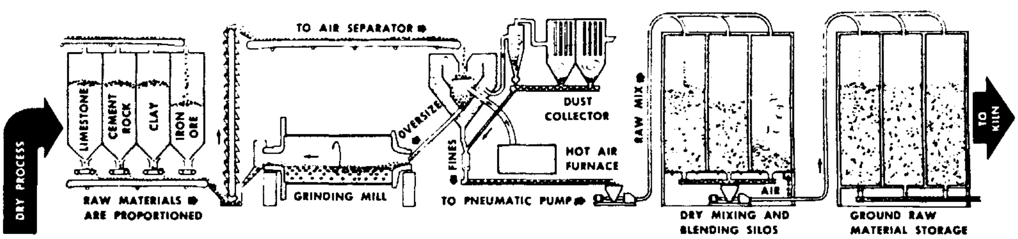
Plant Owner	Location	Limestone Source	Clay/Shale Source
Southwestern Portland Cement Company	Fairborn	Upper Brassfield (Silurian)	Glacial Till (Clay)
General Portland Peninsular Division	Paulding	Detroit River Group Dundee Limestone (Devonian)	Detroit River Group Dundee Formation (Devonian Shale)
Columbia Cement Corporation	East Fultonham	Maxville (Mississippian)	Maxville (Shale)
SME Cement Incorporated	Middlebranch	Putnam Hill (Stark Co.) Vanport (Mahoning Co.) (Pennsylvanian)	Putnam Hill (Shale) Vanport
Columbia Cement Corporation	Sylvania	Dundee Limestone (Devonian)	Dundee

(Sneeringer, 1983)

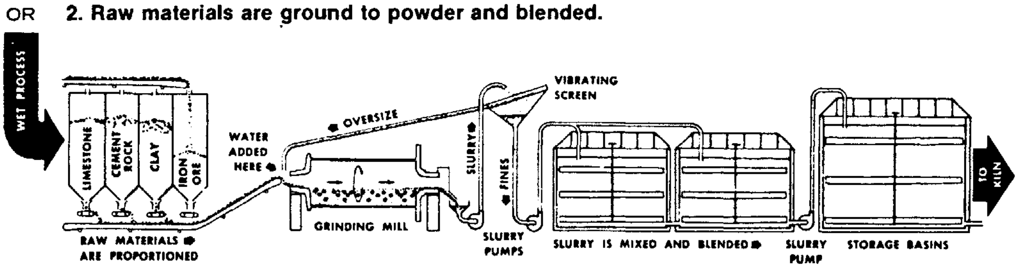
Steps in the manufacture of portland cement



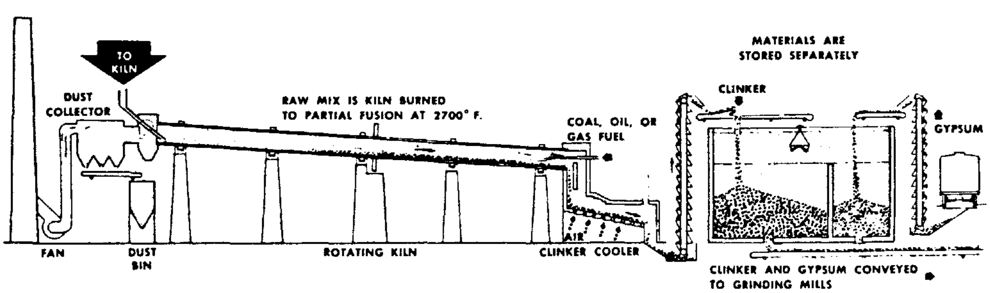
1. Stone is first reduced to 5-in. size, then to ¾ in., and stored.



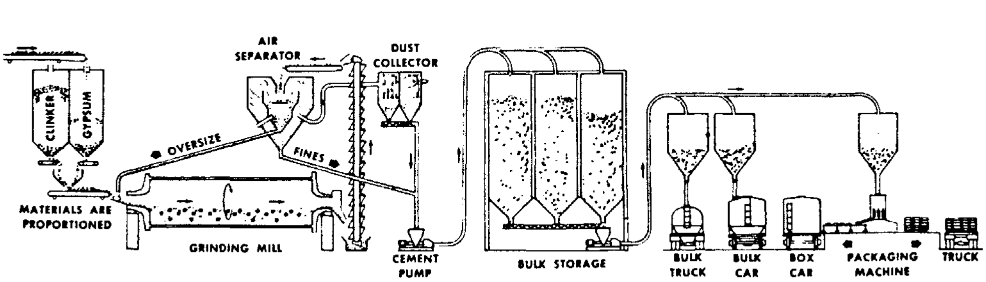
OR **2. Raw materials are ground to powder and blended.**



2. Raw materials are ground, mixed with water to form slurry, and blended.



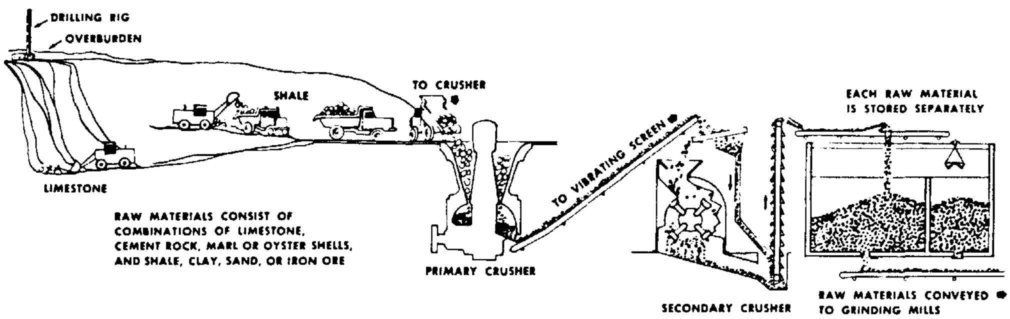
3. Burning changes raw mix chemically into cement clinker.



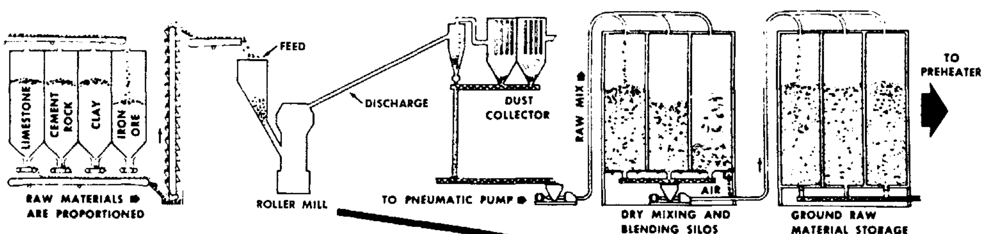
4. Clinker with gypsum is ground into portland cement and shipped.

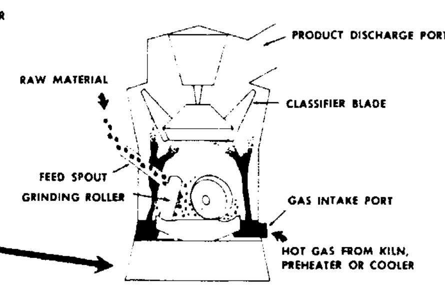
Source: Portland Cement Association

New technology in dry-process cement manufacture



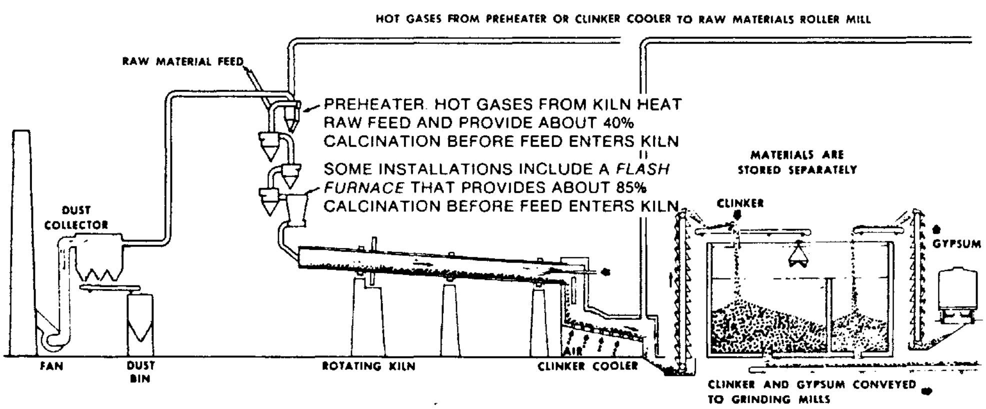
1. Stone is first reduced to 5-in.-size, then to ¾ in., and stored.



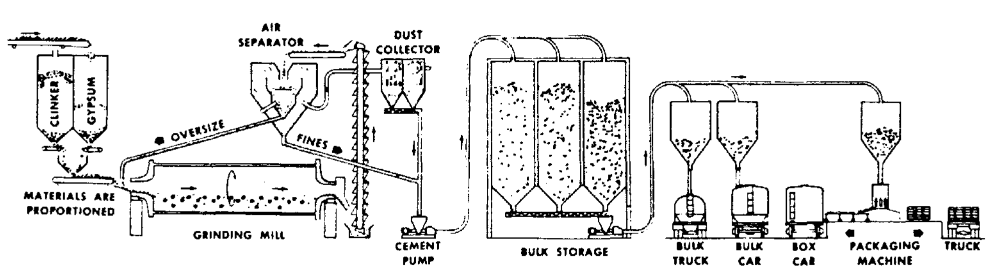


DETAIL OF ROLLER MILL, WHICH COMBINES CRUSHING, GRINDING, DRYING, AND CLASSIFYING IN ONE VERTICAL UNIT

2. Raw materials are ground to powder and blended.



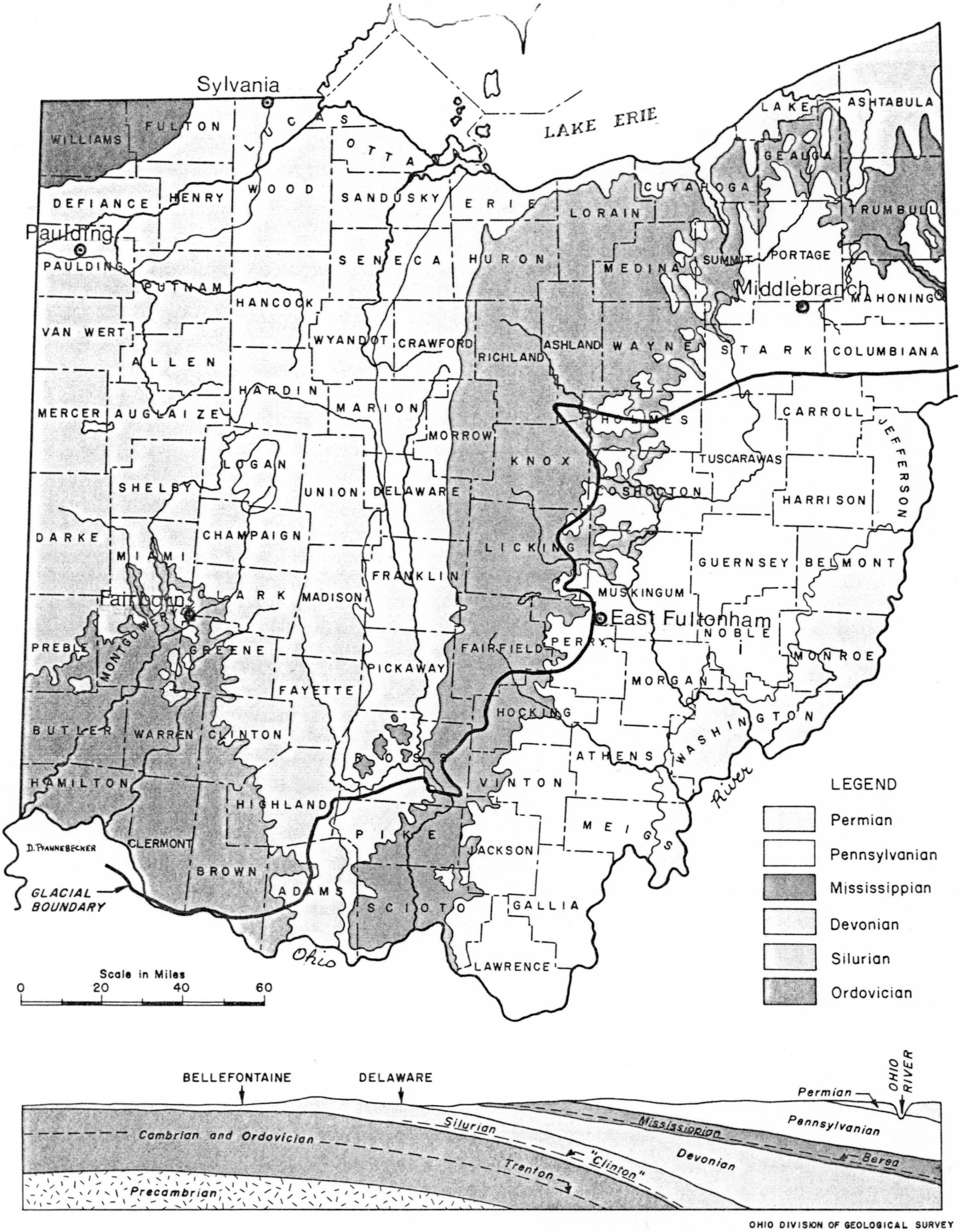
3. Burning changes raw mix chemically into cement clinker. Note four-stage preheater, flash furnaces, and shorter kiln.



4. Clinker with gypsum is ground into portland cement and shipped.

Source: Portland Cement Association

PLANT LOCATIONS



GEOLOGIC MAP OF OHIO

ILLUSTRATION I

Ohio Sales of Raw Materials for
Portland Cement Manufacture

Limestone (amount in tones)			
County	1983	1982	1981
Green	680,576		
Mahoning	470,368		
Montgomery	22,788		
Muskingum	551,415		
Paulding	340,390		
Stark	109,406		
Total for Portland Cement	2,218,023	1,688,383	2,425,942
Total all types	31,061 835	27,573,496	36,695,496

Shale (amount in tons)			
County	1983	1982	1981
Mahoning	46,230		66,345
Muskingum	35,992	42,110	79,490
Total	82,222	42,110	145,835
Total, all uses	1,353,384	1,736,089	1,083,246

Clay (amount in tons)			
County	1983	1982	1981
Green	34,175	33,860	158,257
Paulding	85,483	55,000	76,571
Stark	9,913	25,175	11,730
Total	129,571	114,035	246,558
Total, all uses	958,461	741,310	1,128,593